DON Cost Estimating Standard

DAU Acquisition Community Symposium

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Naval Center for Cost Analysis

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Outline

- Context
  - Managing the Defense Enterprise
  - Whole of Government
  - Acquisition Evolution
- Cost Estimating Standard
  - Establish Need for Estimate
  - Establish Program Baseline
  - Develop Baseline Estimate
  - Conduct Risk & Uncertainty Analysis
  - Verify & Validate Estimate
  - Present and Defend Estimate

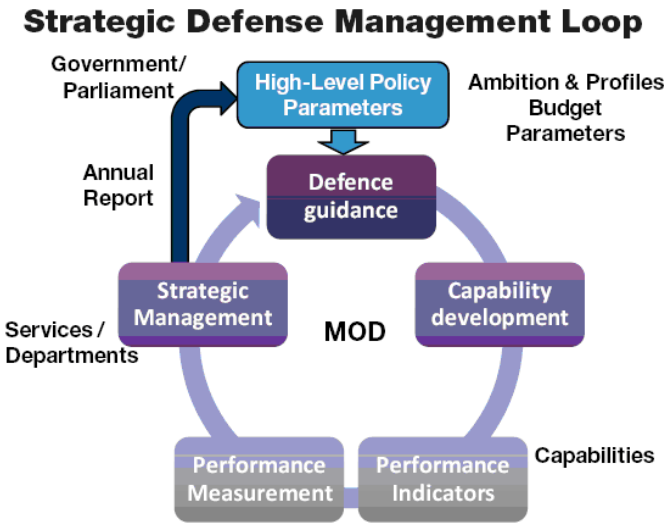
Context

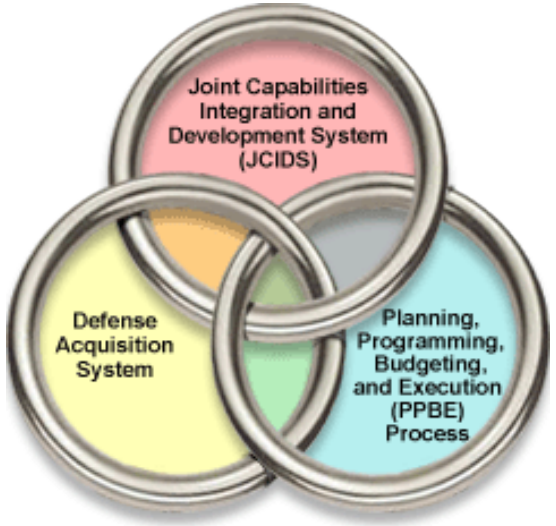
- Managing the defense enterprise
  - "Canonical post-cold war"
- U.S. DoD decision support systems
  - JCIDS
    - Identification and analysis of capability requirements
  - PPBE
    - Strategic planning; program and budget development
  - Acquisition
    - Development and procurement of weapon systems and AISs

Cost-Analysis Support

Ligh t

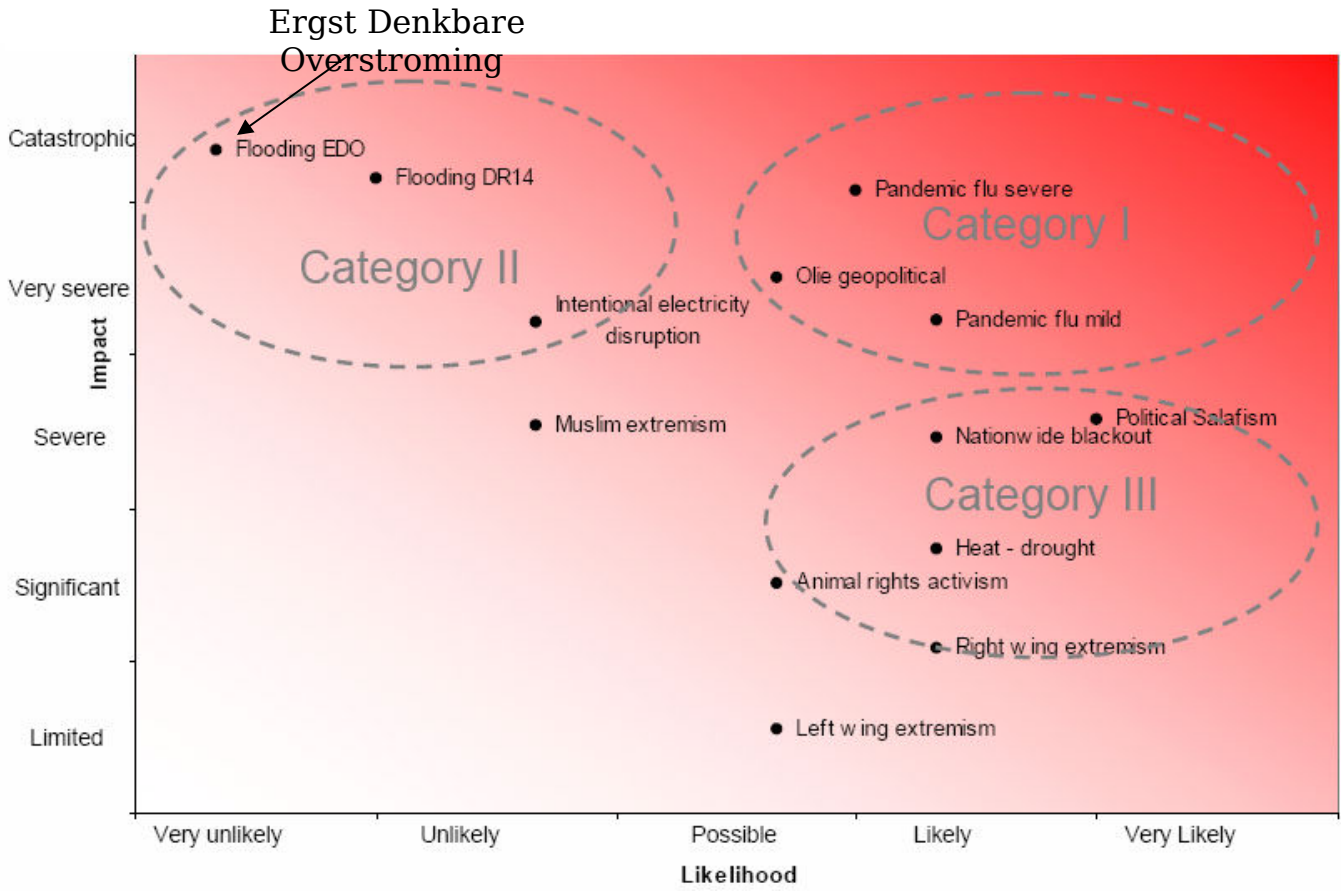
Heavy




Joint Capabilities Integration and Development System (JCIDS)
Defense Acquisition System
Planning, Programming, Budgeting, and Execution (PPBE) Process

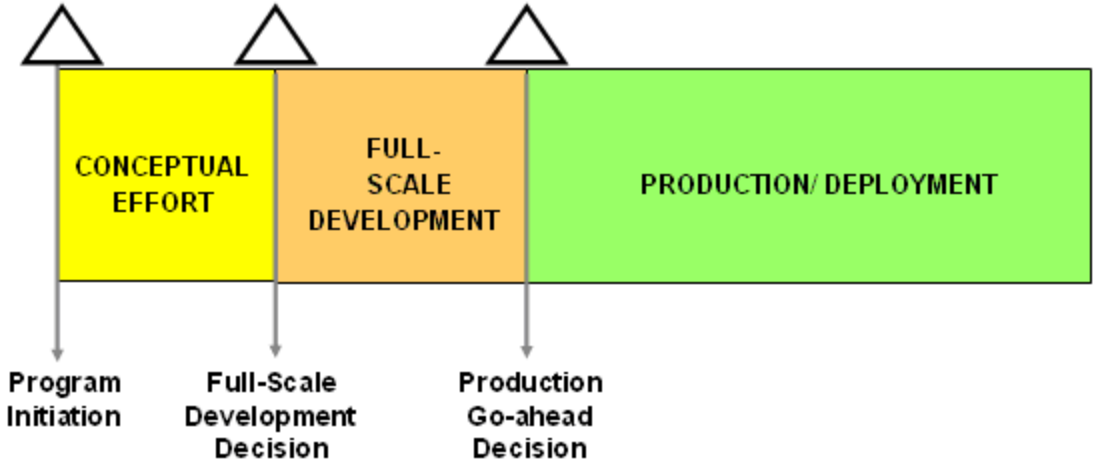
Other Approaches

- D3
  - Defense
  - Diplomacy
  - Developme
- Whole of Governmen
  - Netherlan
  - 2008 analy



History

- First acquisition framework in 197



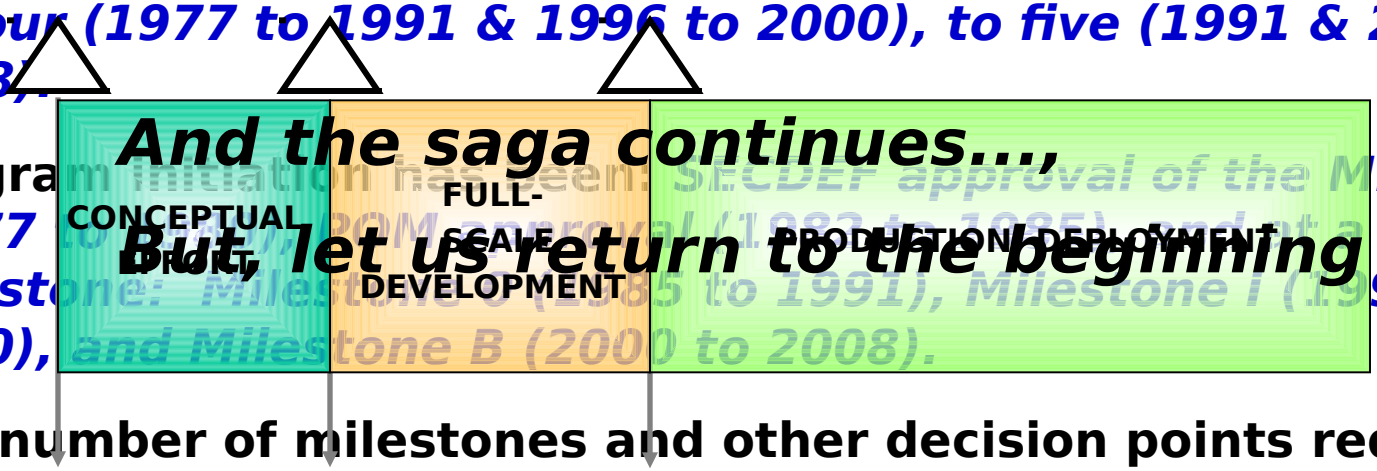
- Decision points: 3
- Phases: 3
- Milestone documents: 1 (Decision Coordinating Paper (DCP))

The 5000 Process

The 5000 docu*tive, two directives, a d*tive and a regulation, a d*al, and a directive an instruction *n*, with combined page count of as little as eight (1971) to as many as 840 (1991). *Currently a directive and an instruction with 90 pages total.*

Major Programs
$50M RDT&E or
$200M
Procurement

Phases of the process have ranged *from three (1971 to 1977) to four (1977 to 1991 & 1996 to 2000), to five (1991 & 2003 to 2008).*



Program Initiation has been: *SECDEF approval of the MENS (1977 to 1980), DAB approval (1982 to 1985), and at a milestone: Milestone C (1985 to 1991), Milestone I (1991 to 2000), and Milestone B (2000 to 2008).*

The number of milestones and other decision points requiring a DoD level review *have been as few as two (1982 - 1985) and as many as seven (2008).*

Program Initiation
Milestone A Decision
Milestone B Decision
Production Go-ahead Decision

Milestone review requirements have ranged from *as few as one document (1971) to over 50 requirements (2008).*

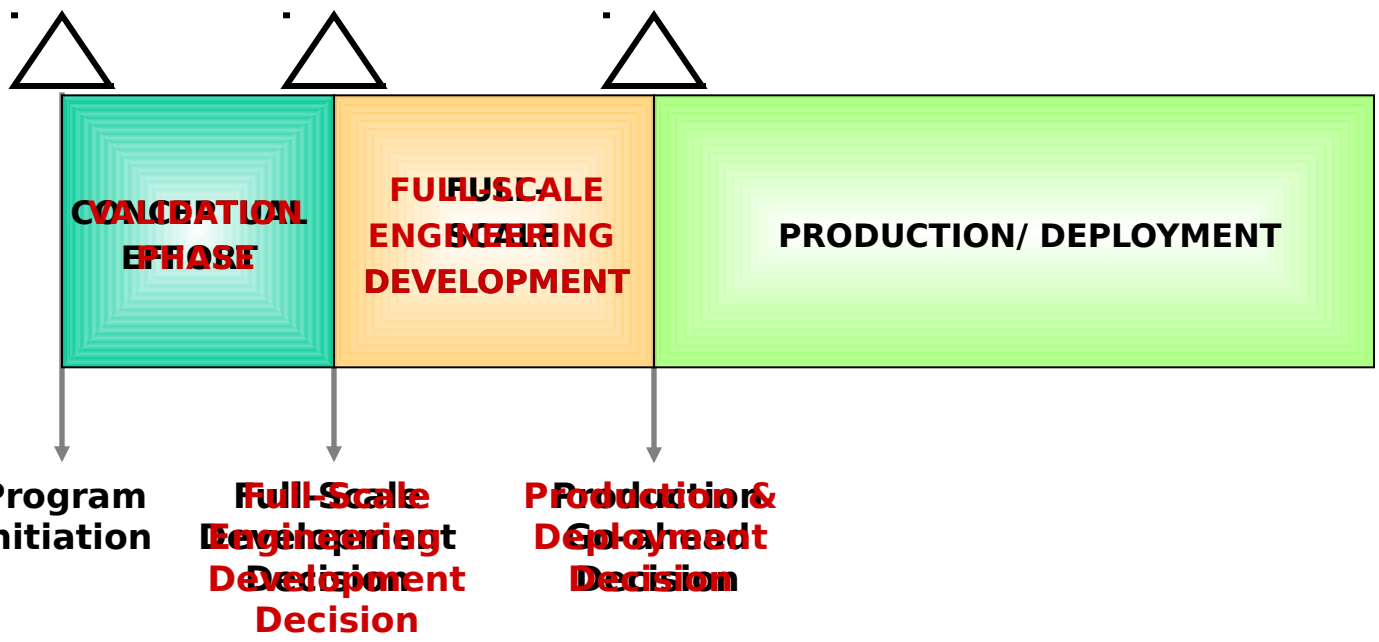
Deputy Secretary of Defense Packard signed the first DoD Directive 5000.1 in 1971. This 8 page document created the Defense Systems Acquisition Review Council (DSARC) and required three major decision points (milestones) with one supporting document. Over the next 37 years this "DoD 5000 process" will be revised 14 times.

The Secretary of Defense was the Milestone Decision Authority for MDAPs from 1971 to 1991. *Currently, it is the USD(AT&L).*

The first DoD - level requirements document appeared in 1977,

The 5000 Process

Major Programs
$50M RDT&E or
$200M
Procurement
(FY 1990 dollars)

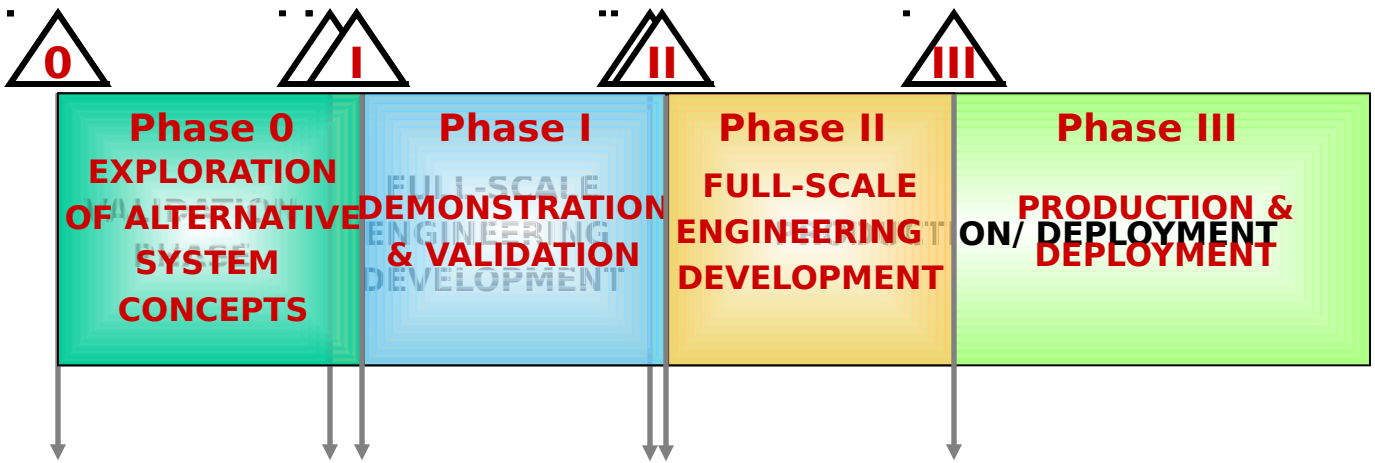


- DSARC Created
- SECDEF decisions documented in approved Decision Coordinating Paper (DCP)

The 5000 Process

Major Programs

$75M RDT&E or
$300M
(FY1972 dollars)
Procurement

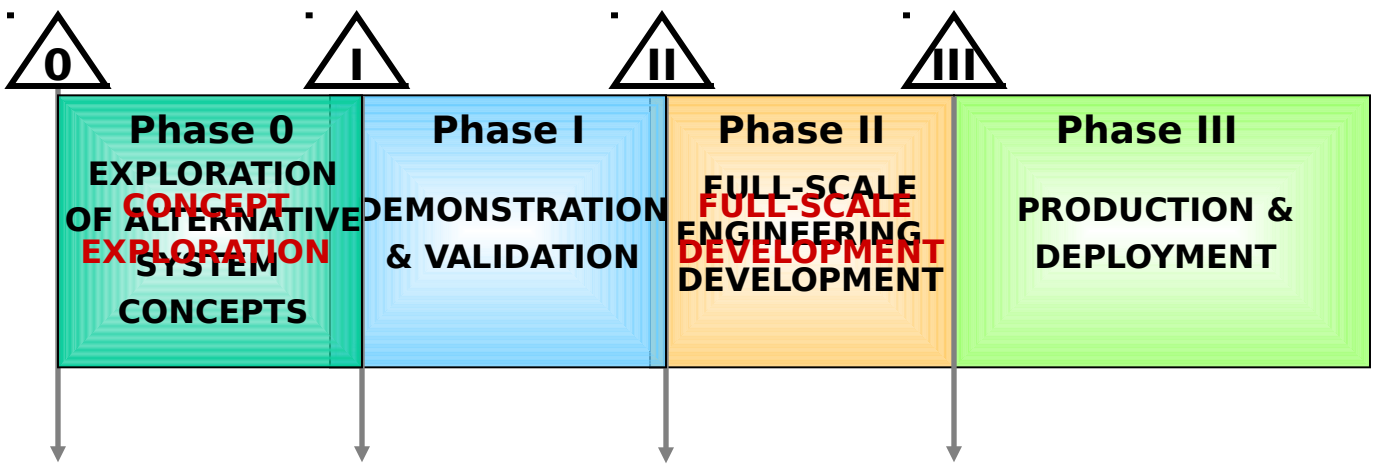


ilestones are numbered
ission Element Need Statement (MENS) appears as first DoD-level requirements document

The 5000 Process

1980

Major Programs
$200M RDT&E or
$300M Procurement
(FY1980 dollars)

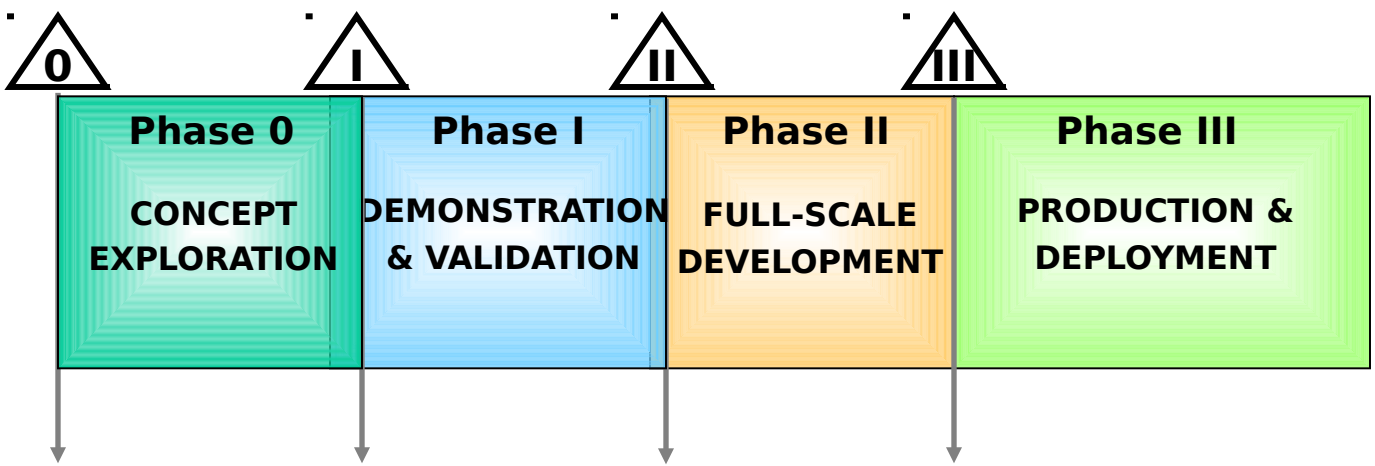


- Milestones are numbered
- SECDEF Decision Memorandum (SDDM) implemented to document milestone decisions
- Mission Element Need Statement (MENS) appears as first DoD-level requirements document

The 5000 Process

1982

Major Programs
$200M RDT&E or
$1B Procurement
(FY 1980 dollars)

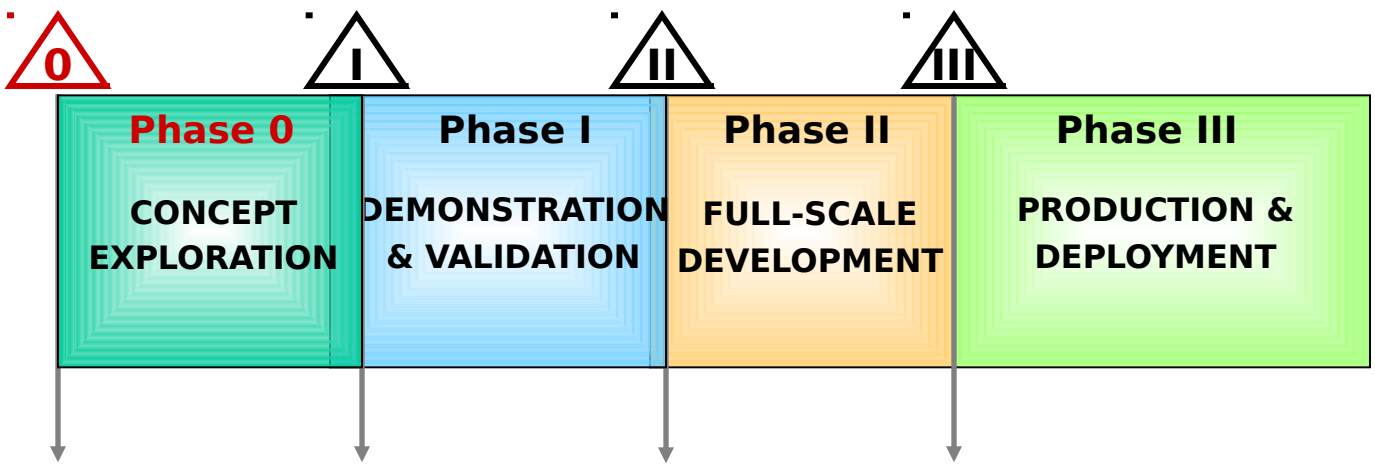


- SECDEF Decision Memorandum (SDDM) implemented to document milestone decisions
- Milestone 0 deleted
- May proceed into FSD with delayed MS II – contracts must be written so program can be terminated at least cost to government

The 5000 Process

1985

Major Programs
$200M RDT&E or
$1B Procurement
(FY1980 dollars)

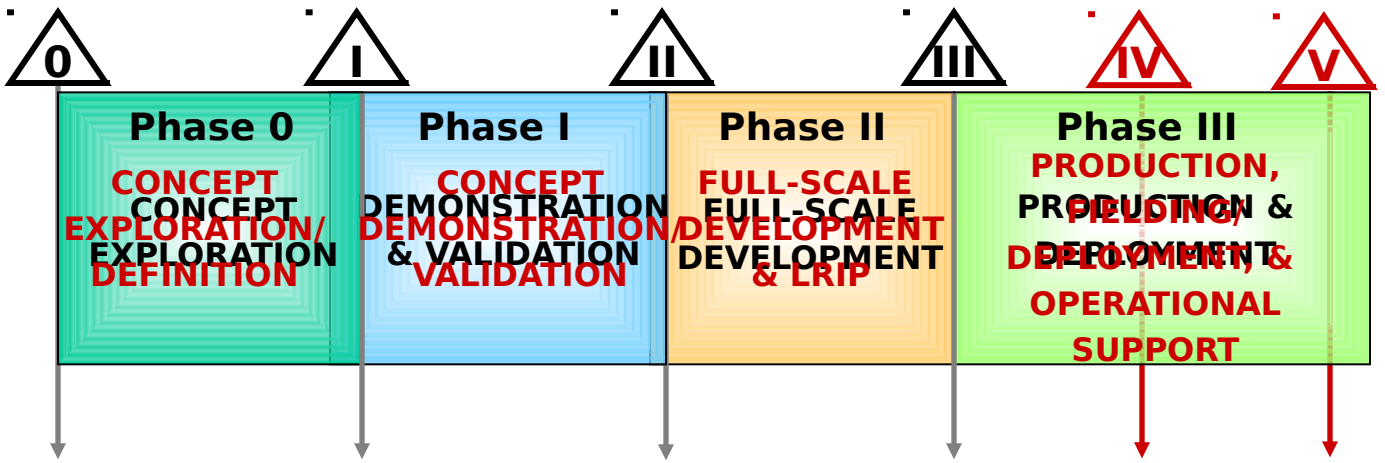


- Milestone 0 deleted
- May proceed into FSD with delayed MS II – contracts must be written so program can be terminated at least cost to government

The 5000 Process

1987

Major Programs
$200M RDT&E or
$1B Procurement
(FY1980 dollars)

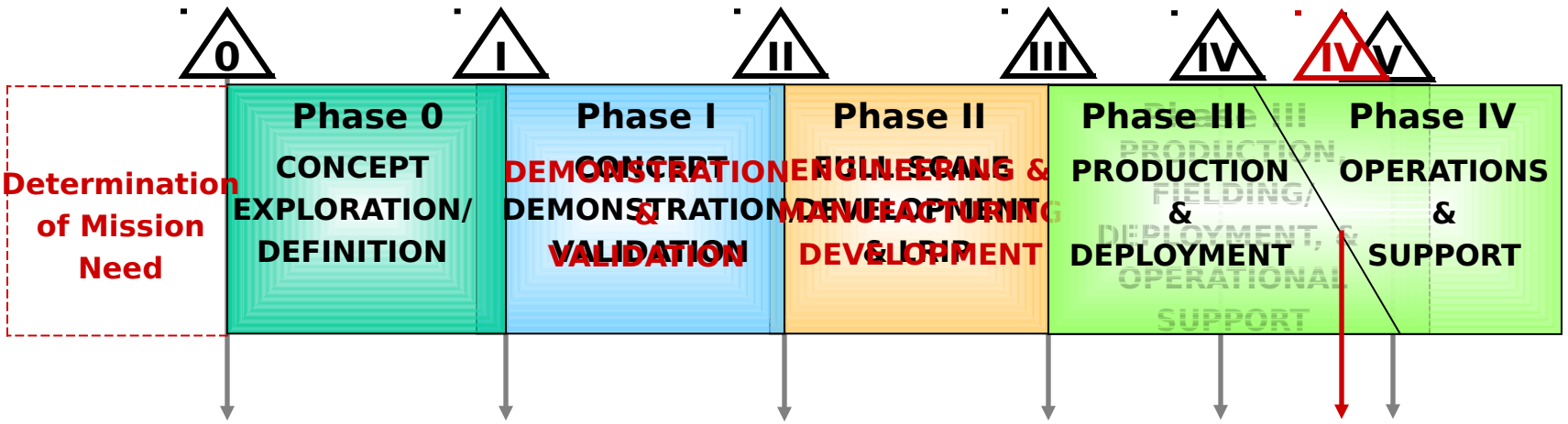


- Milestone 0 returns
- Joint Requirements Management Board (JRMB) renamed JROC
- DSARC renamed JRMB; JRMB renamed DAB
- Competitive Prototyping Strategy required by law and DoDI 5000.2

The 5000 Process

1991

Major Programs
$200M RDT&E or
$1B Procurement
(FY 1980 dollars)



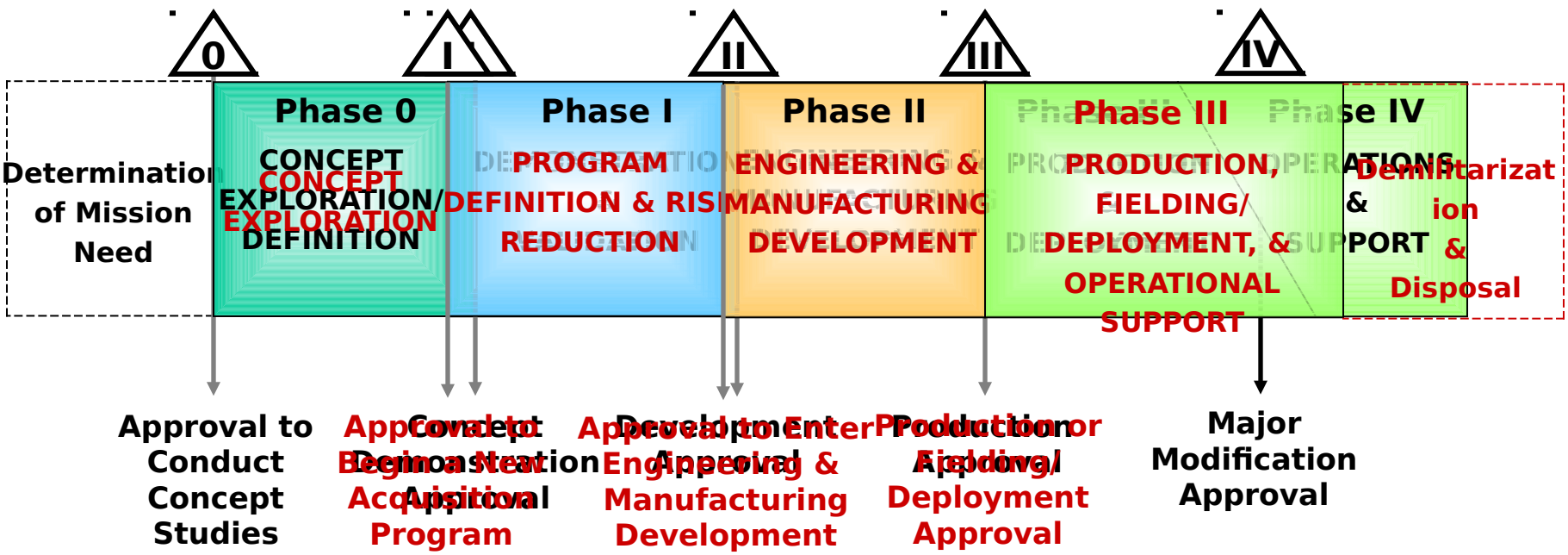
- Joint Requirements Management Board (JRMB) renamed JROC
- DSARC renamed JRMB; JRMB renamed DAB
- Competitive Prototyping Strategy required by law and DoDI 5000.2

- JROC approved MNS replaces SECDEF approved JMSNS at MS 0
- Operational Requirements Document (ORD) appears in DoDI 5000.2, required at MS II and III

The 5000 Process

1996

Major Programs
$300M RDT&E or $1.8B Procurement (FY1990 dollars)



- Acquisition Decision Memorandum (ADM) signed by USD(Acq) replaces SDDM
- Service-unique phases eliminated
- ACAT IC program delegated
- JROC approved MNS replaces SECDEF approved JMSNS at MS 0
- Operational Requirements Document (ORD) appears in DoDI 5000.2, required at MS II and III

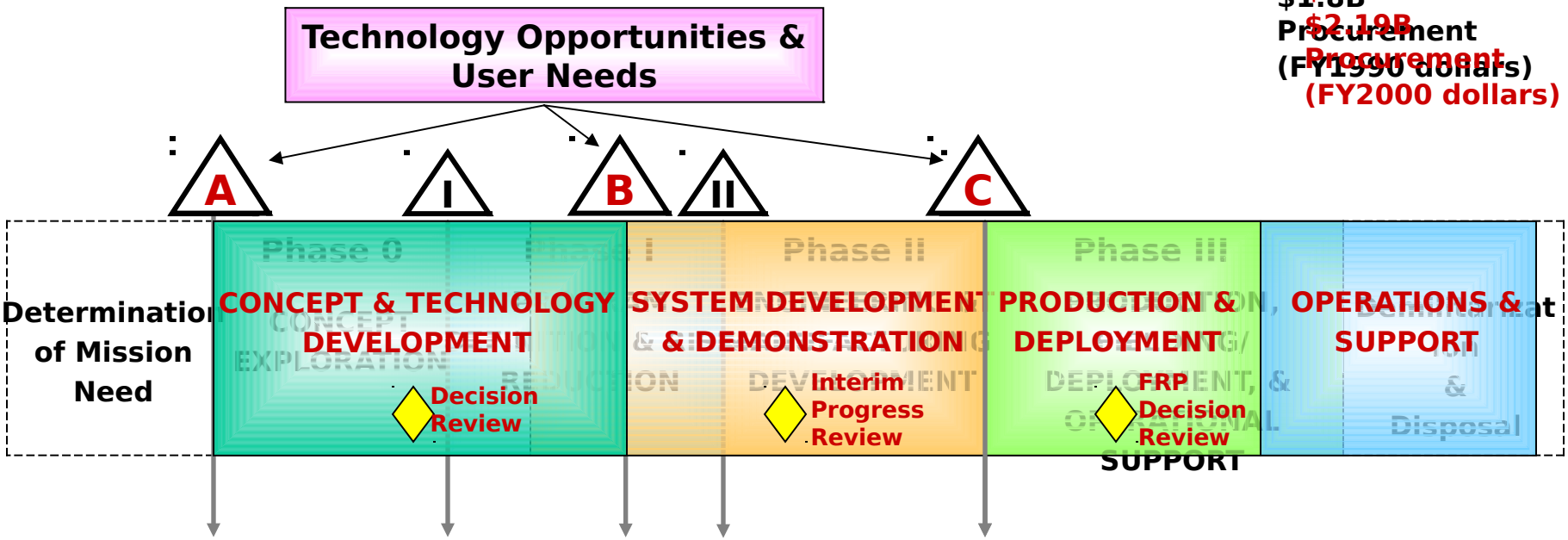
- ~~Program Initiation moved to Milestone I~~
- ~~AIS acquisition programs folded into the DoD 5000 process~~
- ~~Competitive Prototyping requirement eliminated~~

The 5000 Process

2000

Major Programs
$300M RDT&E or
$1.8B Procurement
(FY1990 dollars)

Major Programs
$365M RDT&E or
$2.19B Procurement
(FY2000 dollars)

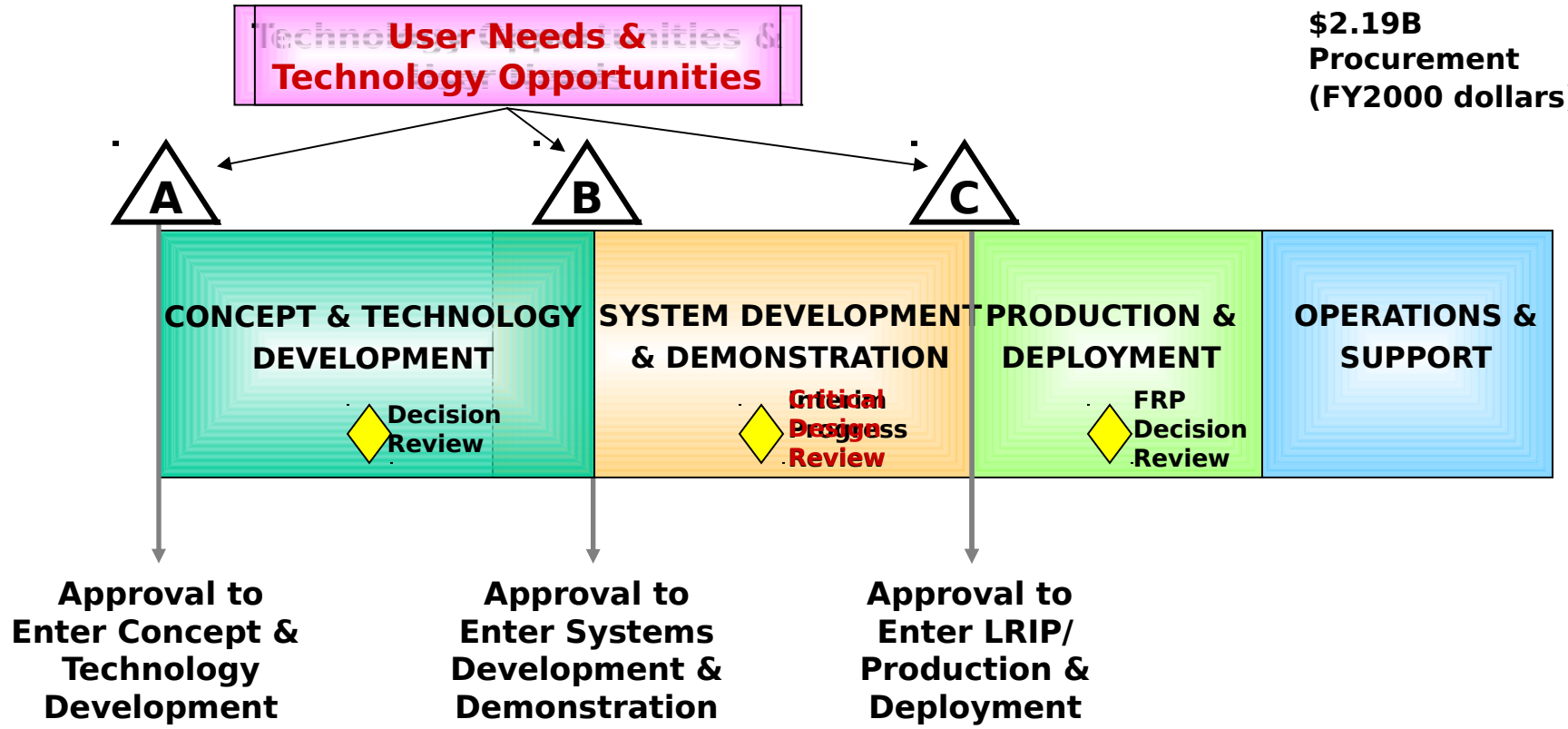


- Program Initiation moved to Milestone I
- AIS acquisition programs folded into the DoD 5000 process
- Competitive Prototyping eliminated

The 5000 Process

2002

Major Programs
$365M RDT&E or
$2.19B
Procurement
(FY2000 dollars)



- Program Initiation at MS B
- Commitment to Production at MS C (LRIP)
- Evolutionary Acquisition (EA) becomes preferred approach

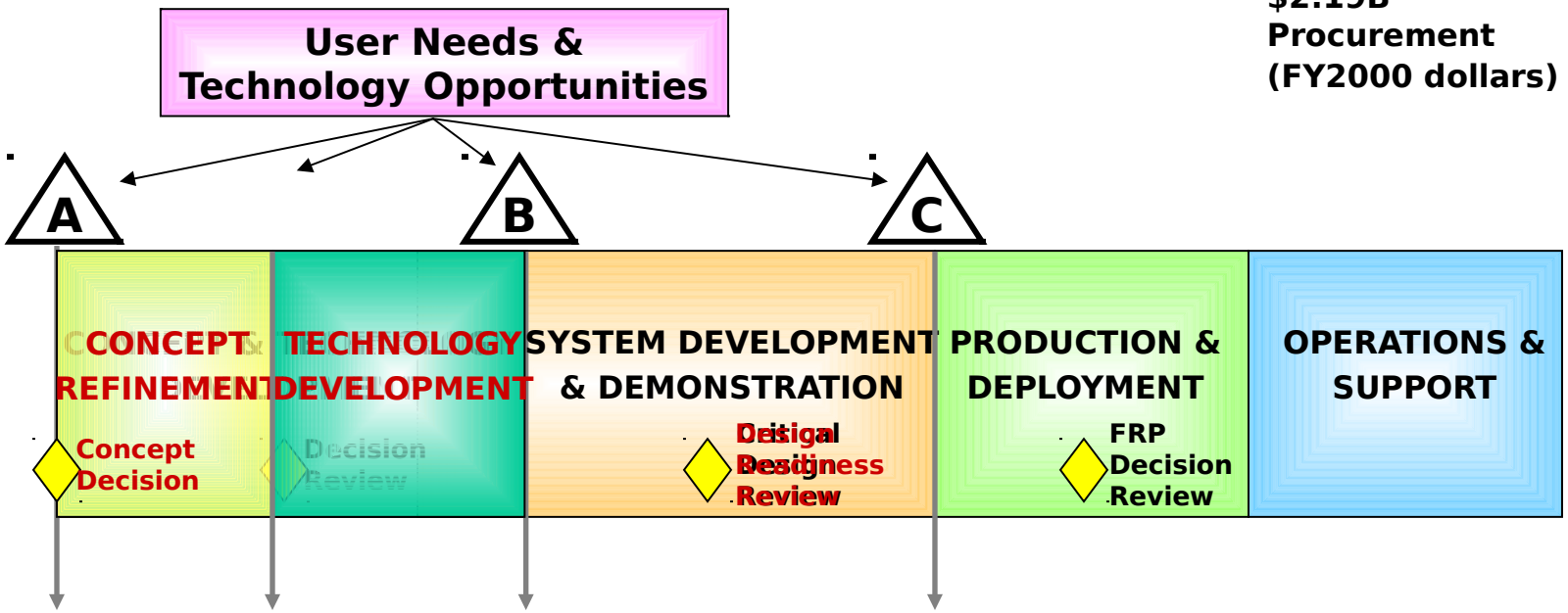
DEPSECDEF signs and cancels DoD 5000 documents

Interim Guidance documents issued: "Defense Acquisition" for basic policy, and "Operation of the Defense Acquisition System" for implementation procedures

- DoD 5000.2-R becomes "Interim Defense Acquisition Guidebook"

The 5000 Process

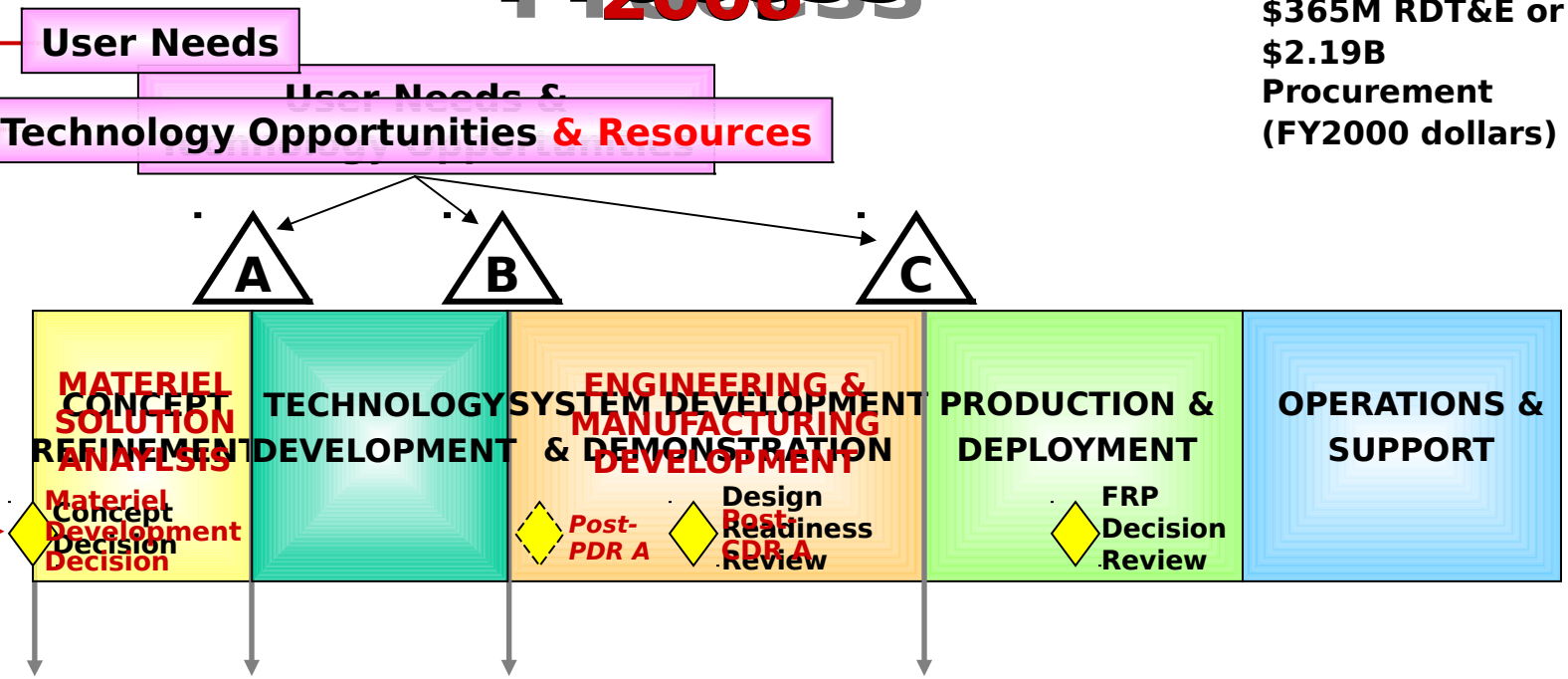
Major Programs
$365M RDT&E or $2.19B Procurement (FY2000 dollars)



- DEPSECDEF cancels all three DoD 5000 documents and Interim Guidance documents issued "Defense Acquisition" for basic policy, and "Operation of the Defense Acquisition System" for implementation procedures
- DoD 5000.2-R becomes "Interim Defense Acquisition Guidebook"

The 5000 Process 2008

Major Programs
$365M RDT&E or $2.19B Procurement (FY2000 dollars)



- Defense Acquisition Guidebook (DAG) comes on-line
- Joint Capabilities Integration and Development System (JCIDS) is born. MNS and ORD replaced.
- Initial Capabilities Document required prior to Concept Decision
- Capability Development Document required at MS B; Capability Production Document at MS C

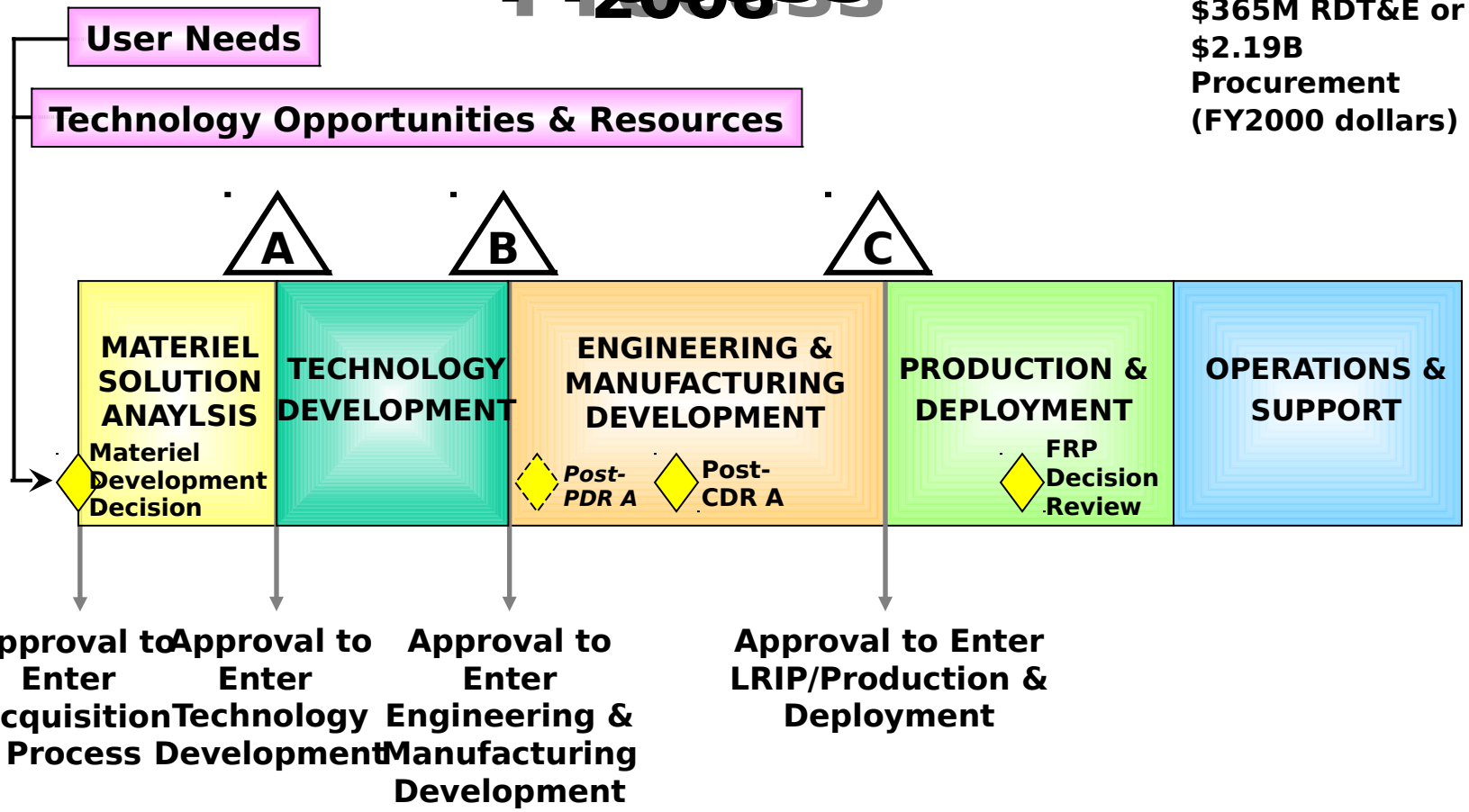
Materiel Development Decision precedes entry into any phase of the acquisition process

Competitive Prototyping returns; required during Technology Development Phase

Preliminary Design Review (PDR) after MS B required a Post-PDR assessment by the MDA

The 5000 Process 2003

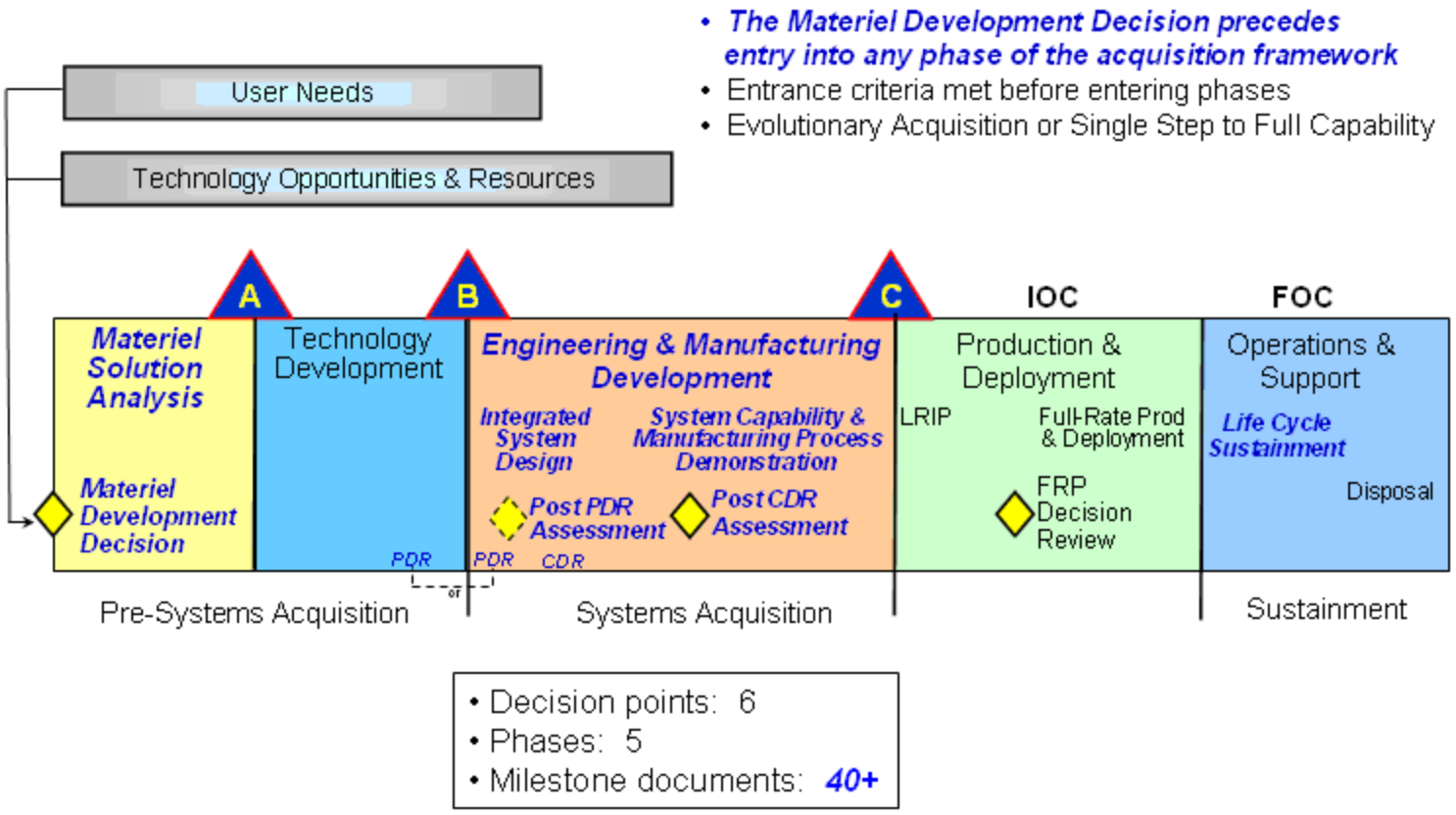
Major Programs
$365M RDT&E or $2.19B Procurement (FY2000 dollars)



- Materiel Development Decision precedes entry into any phase of the acquisition process
- Competitive Prototyping returns; required during Technology Development Phase
- Preliminary Design Review (PDR) after MS B requires a Post-PDR Assessment by the MDA

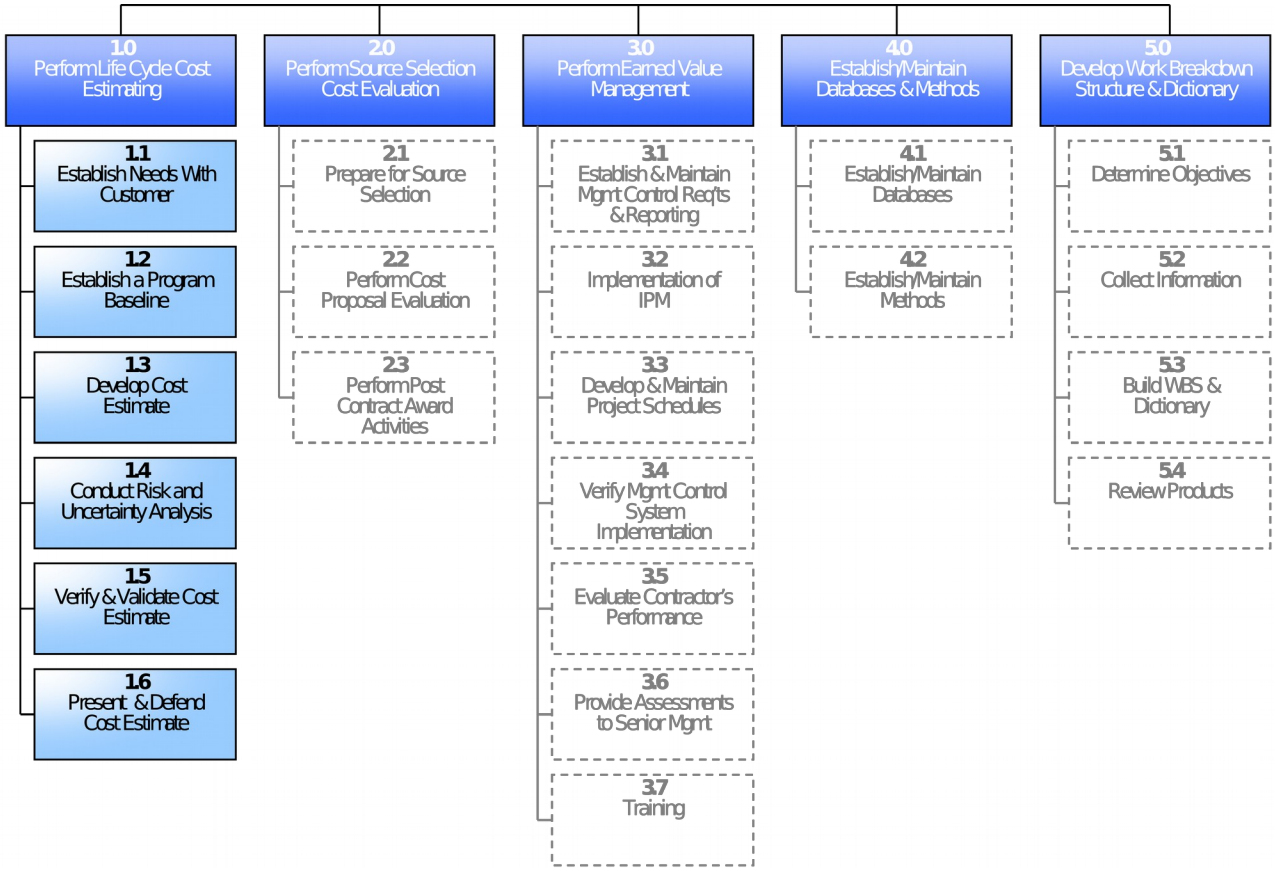
History

- Acquisition framework in 2008

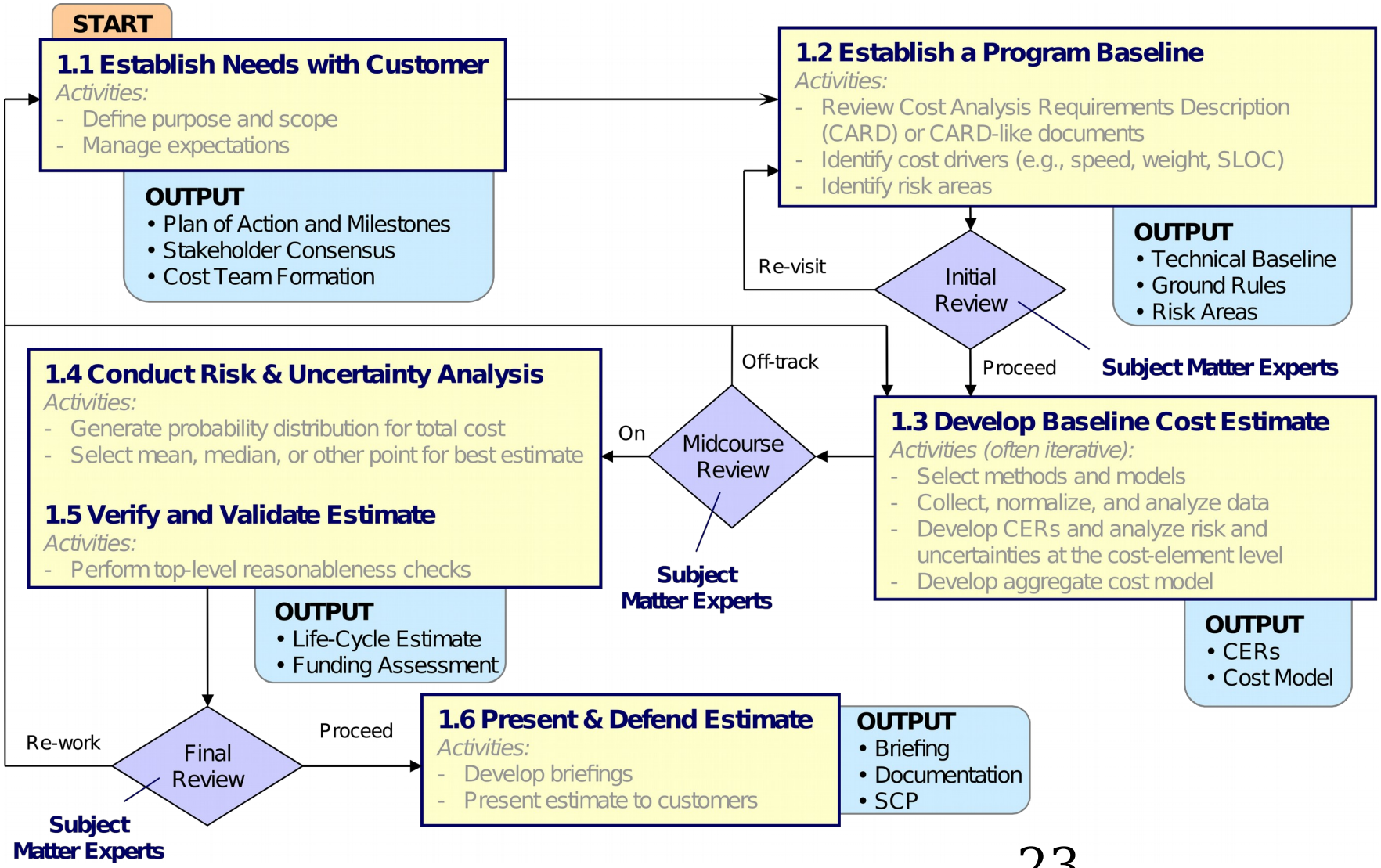


DON Cost Estimating Standard

Technique Universe


1.0 Perform Life Cycle Cost Estimating
1.1 Establish Needs With Customer
1.2 Establish a Program Baseline
1.3 Develop Cost Estimate
1.4 Conduct Risk and Uncertainty Analysis
1.5 Verify & Validate Cost Estimate
1.6 Present & Defend Cost Estimate
2.0 Perform Source Selection Cost Evaluation
2.1 Prepare for Source Selection
2.2 Perform Cost Proposal Evaluation
2.3 Perform Post Contract Award Activities
3.0 Perform Earned Value Management
3.1 Establish & Maintain Mgmt Control Req'ts & Reporting
3.2 Implementation of IPM
3.3 Develop & Maintain Project Schedules
3.4 Verify Mgmt Control System Implementation
3.5 Evaluate Contractor's Performance
3.6 Provide Assessments to Senior Mgmt
3.7 Training
4.0 Establish/Maintain Databases & Methods
4.1 Establish/Maintain Databases
4.2 Establish/Maintain Methods
5.0 Develop Work Breakdown Structure & Dictionary
5.1 Determine Objectives
5.2 Collect Information
5.3 Build WBS & Dictionary
5.4 Review Products

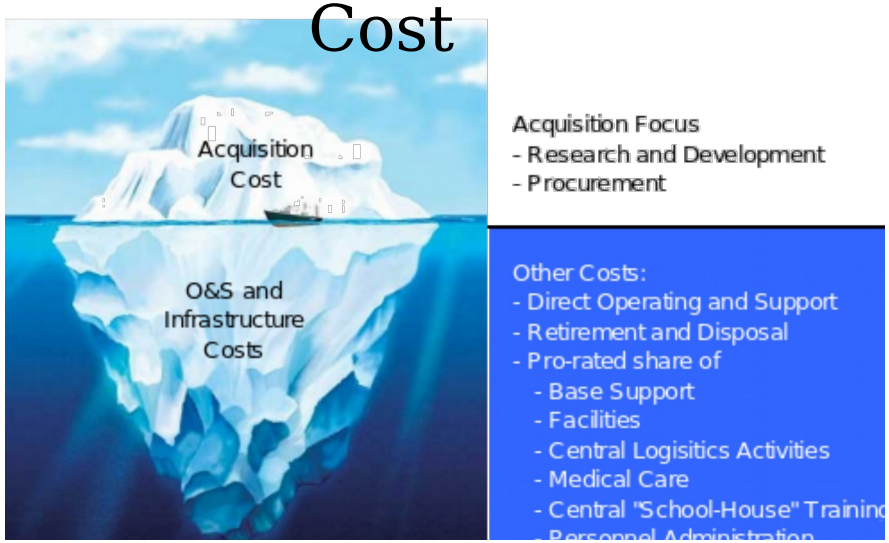
Process


START
1.1 Establish Needs with Customer
Activities:
- Define purpose and scope
- Manage expectations
OUTPUT
• Plan of Action and Milestones
• Stakeholder Consensus
• Cost Team Formation
1.2 Establish a Program Baseline
Activities:
- Review Cost Analysis Requirements Description (CARD) or CARD-like documents
- Identify cost drivers (e.g., speed, weight, SLOC)
- Identify risk areas
OUTPUT
• Technical Baseline
• Ground Rules
• Risk Areas
Re-visit
Initial Review
Proceed
Subject Matter Experts
1.3 Develop Baseline Cost Estimate
Activities (often iterative):
- Select methods and models
- Collect, normalize, and analyze data
- Develop CERs and analyze risk and uncertainties at the cost-element level
- Develop aggregate cost model
OUTPUT
• CERs
• Cost Model
Off-track
On
Midcourse Review
Subject Matter Experts
1.4 Conduct Risk & Uncertainty Analysis
Activities:
- Generate probability distribution for total cost
- Select mean, median, or other point for best estimate
1.5 Verify and Validate Estimate
Activities:
- Perform top-level reasonableness checks
OUTPUT
• Life-Cycle Estimate
• Funding Assessment
Re-work
Final Review
Proceed
Subject Matter Experts
1.6 Present & Defend Estimate
Activities:
- Develop briefings
- Present estimate to customers
OUTPUT
• Briefing
• Documentation
• SCP

Establish Need for Estimate

- Identify purpose
  - E.g., gate or MS review; AoA; POM build; special studies
- Define scope
  - Complexity, timeframe, elements of total ownership costs
- Determine resource requirements
  - In-house and contractor support
- Evaluate availability of resources
  - Match against workload
- Identify and resolve issues
  - Identify resource/scheduling conflicts
- Generate plan
  - Develop a formal plan of action with tasks, milestones, and deliverables

Total Ownership Cost



Obtain approval from stakeholders

Establish Program Baseline

- Identify/request baseline parameters
  - Develop structure to include all information necessary to perform the analysis
- Collect & evaluate baseline parameters
  - Use crosschecks to ensure the baseline accurately defines the system or concept under consideration
- Document technical and programmatic baseline
  - Develop CARD and a collection of all other documentation that supports specification of the baseline
- Conduct technical and programmatic baseline review meeting
  - Per SECNAV instruction, the System Command assesses the accuracy of baseline program parameters in the CARD prior to formal submission

Not one-step-and-stop activities; cost competency works continuously with program office and stakeholders

New requirement

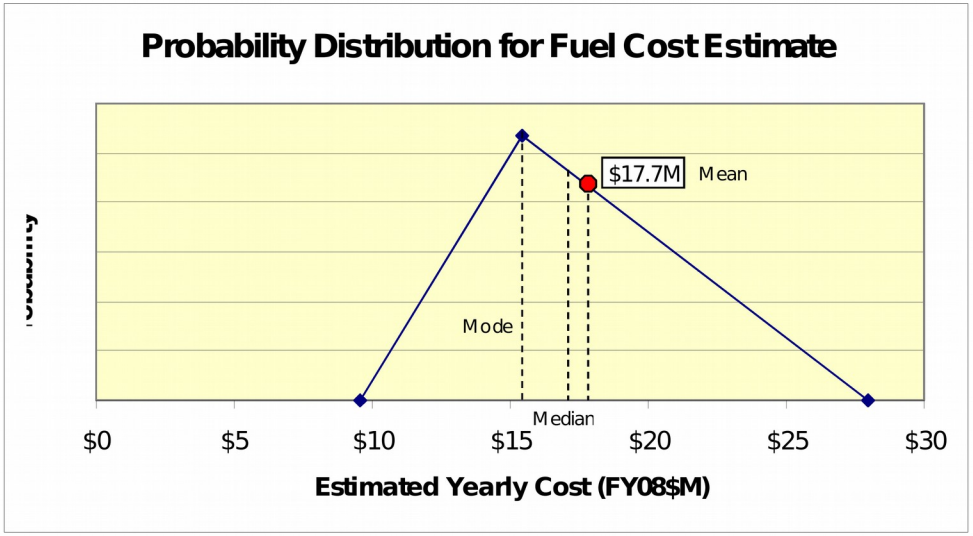
Establish Program Baseline

Sample of Required Information

Element of Information	
System description and characteristics	Time-phased system quantity requirements
System overview	
System performance parameters and characteristics	System manpower requirements
Technical and physical description	
Work breakdown structure	System activity rates (operating tempo)
Summary of maturity levels of critical technologies	
Software description and sizing information	Facilities requirements
Interfaces with other systems	
Subsystem descriptions, as appropriate	Summary of security or program protection features
System suitability factors	Summary of environment, safety, and occupational health considerations
Reliability/Maintainability/Availability	
PM's assessment of program risk & mitigation measures	System milestone schedule
System operational concept	Summary of acquisition plan or strategy
Organizational/unit structure	
Basing and deployment description (peacetime, contingency, and wartime)	Plans for system disposal
	Track to prior CARD
System sustainment concept	
System logistics concept	Approved or proposed CSDR plan
Maintenance concept	
Supply management concept	
Transportation concept	
Software maintenance concept	
System training concept	

Develop Baseline Estimate

- Develop an estimating approach
- Collect, validate, normalize, and analyze data
- Develop CERs and analyze risks and uncertainties
- Develop the aggregate cost model
- Run the model

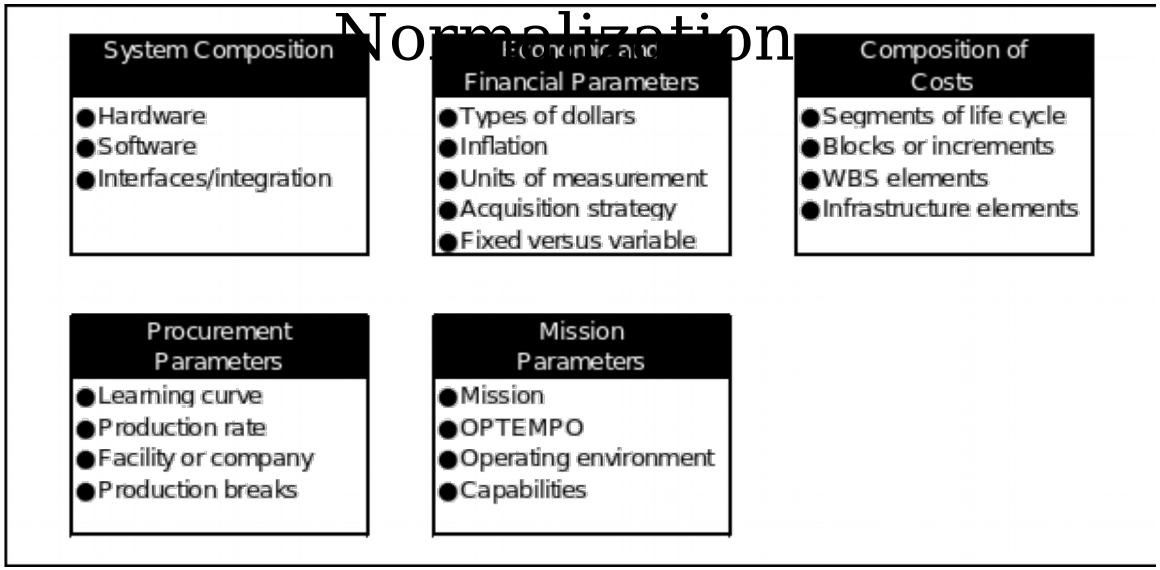


Assess risk and uncertainties for each element of the estimate <u>at the same time</u> that the point estimate is developed

Sample Sub-processes

- Collect, Validate, Normalize, & Analyze Data
  - Collect data
    - Develop and execute plan
  - Validate data
    - Currency, applicability, accuracy
  - Normalize data
  - Analyze data
    - Scatter plots, influence diagrams, classification trees, outlier analysis, data-mining algorithms

Dimensions of Normalization

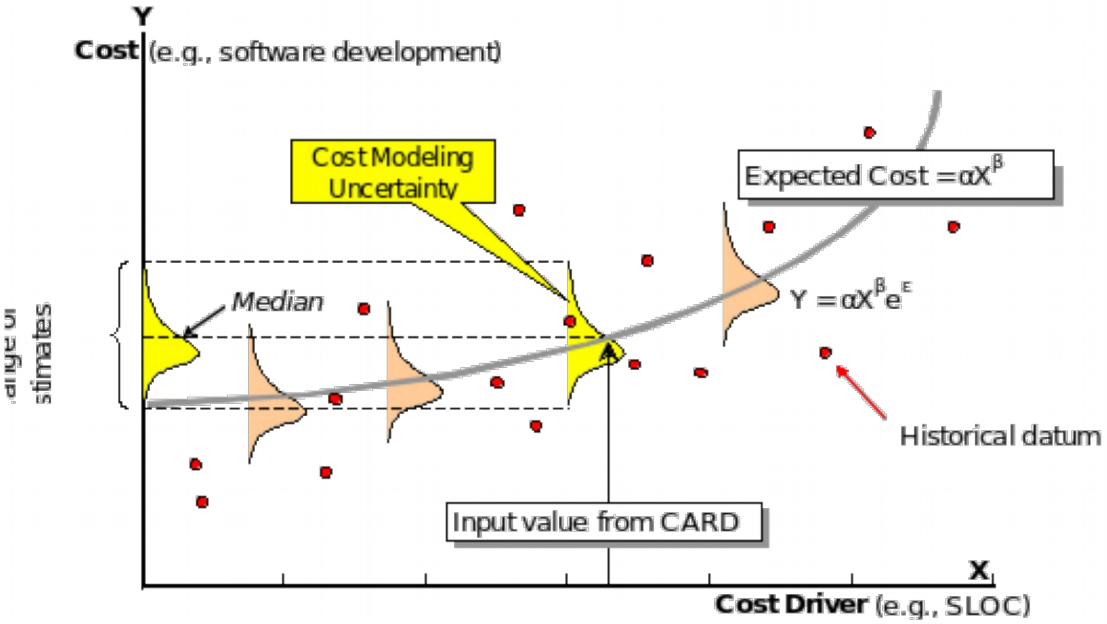


"Life cycle costing is a data driven process, as the amount, quality and other characteristics of the available data often define what methods and models can be applied, what analyses can be performed, and hence, the results that can be achieved."

Dr. Thomas Pedersen, Denmark; NATO Cost Estimating Task Group

Sample Sub-processes

- Develop CERs & Analyze Risks and Uncertainties
  - Develop CERs
    - Show results, including t and F statistics, R-squared, and standard error of the estimate
  - Document development of CERs
    - Data sources, exclusion of outliers, regression equations that failed
  - Analyze risks and uncertainties
    - For each cost element
  - Conduct methodological review meeting



Risk & Uncertainty Analysis

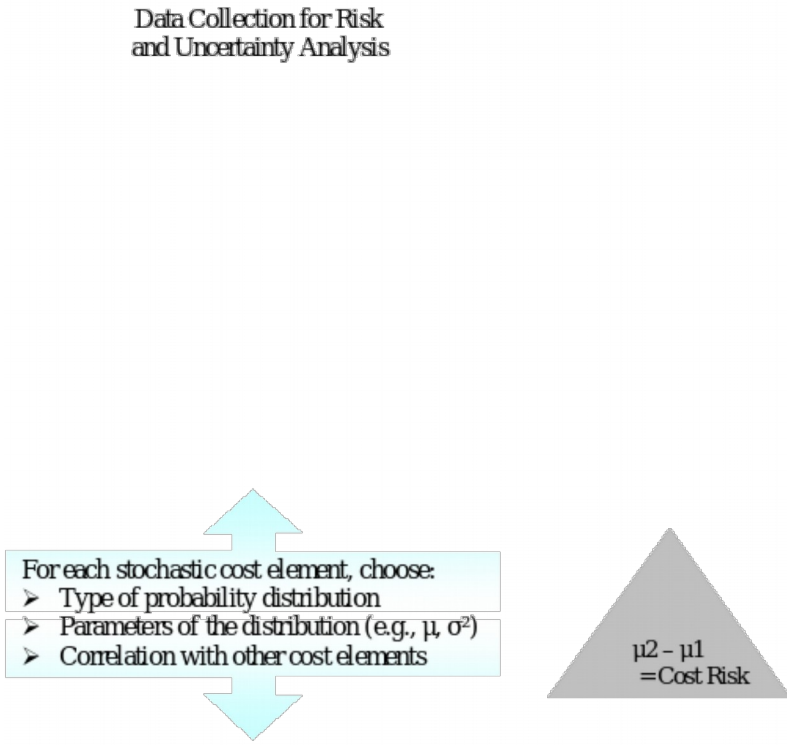
- Choose method of analysis
  - Sensitivity analysis, Monte Carlo simulation, scenario-based analysis
- Collect data
  - Major elements of risk; correlations between cost elements when MC simulation employed
- Run the analysis
  - Different approaches for different techniques
- Analyze results
  - Check for accuracy, clarity, and completeness
- Choose risk-adjusted point estimate
  - Serves as a single-number "best estimate" of the unknown cost of the program
  - Unless directed otherwise, use the mean, which usually lies between the 50th and 60th percentiles in a log-normal cumulative probability distribution
- Allocate and phase costs

"Employment of more than one technique, such as the latter two which are fundamentally different in approach, will add insight into the analysis and credence to the results. This, indeed, is a best practice."

DON CES, page 30

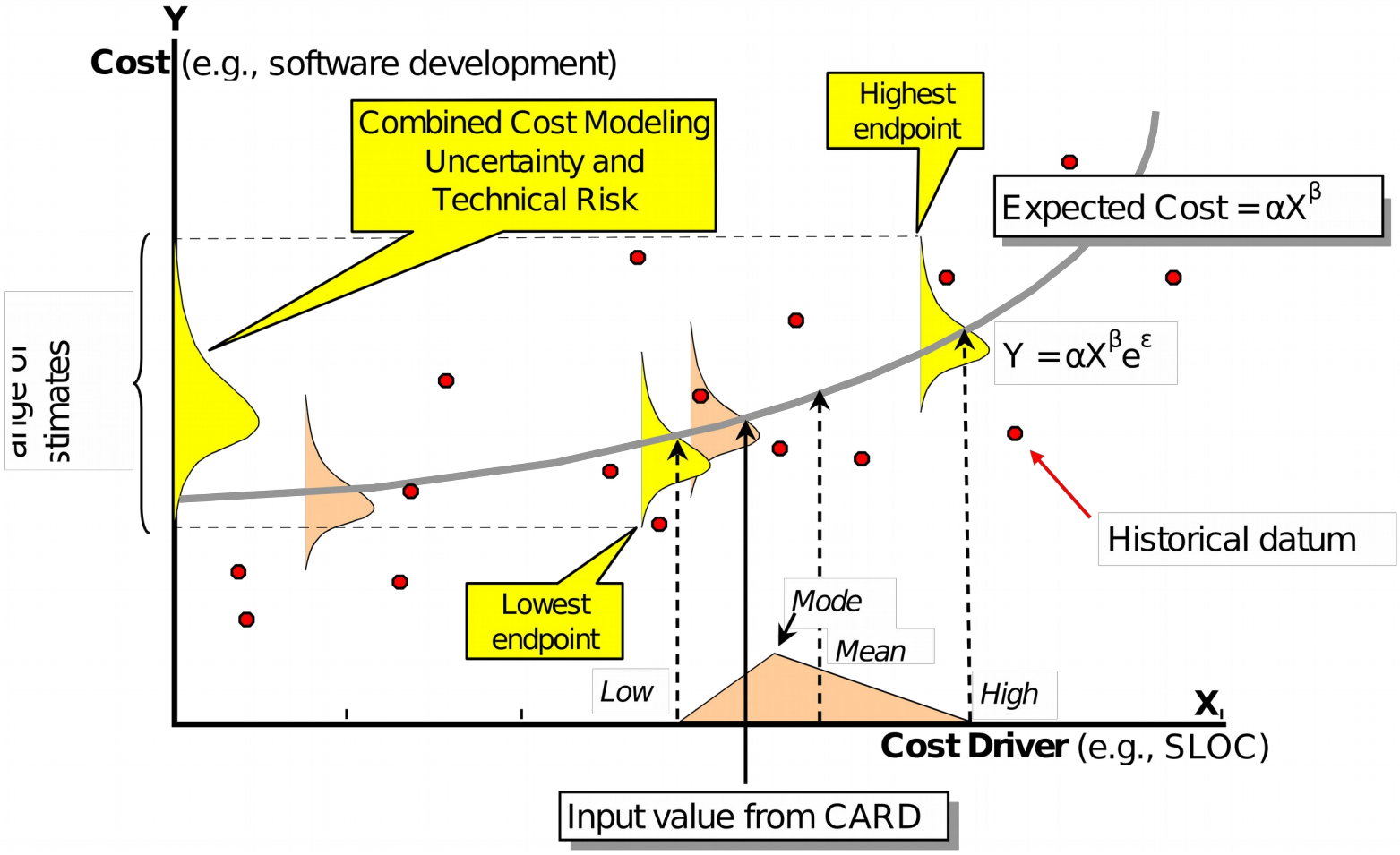
Monte Carlo Simulation

- In this variant, one among several in use,
  - Generate baseline PDF
    - Regard as fixed the values of explanatory variables
    - Captures modeling uncertainty
  - Generate risk-adjusted PDF
    - Regard as stochastic the values of explanatory variables
    - Captures modeling uncertainty *and* risk
  - Compute delta in sample means


Data Collection for Risk and Uncertainty Analysis
For each stochastic cost element, choose:
Type of probability distribution
Parameters of the distribution (e.g., μ, σ²)
Correlation with other cost elements
μ2 – μ1 =Cost Risk

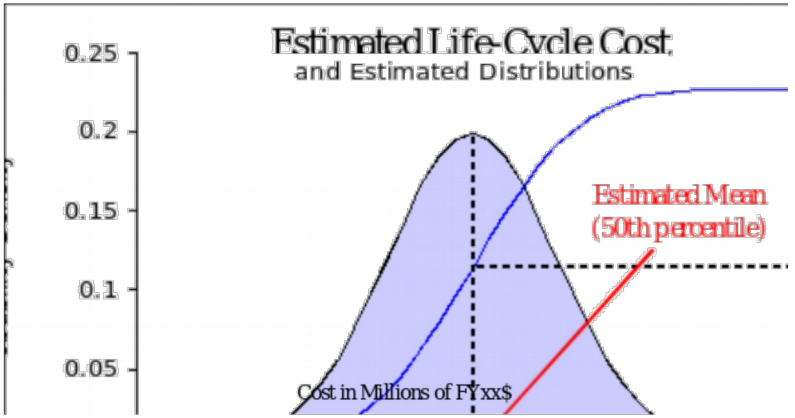
Note: See AFCAA's "Cost Risk and Uncertainty Handbook" for details

CER Example

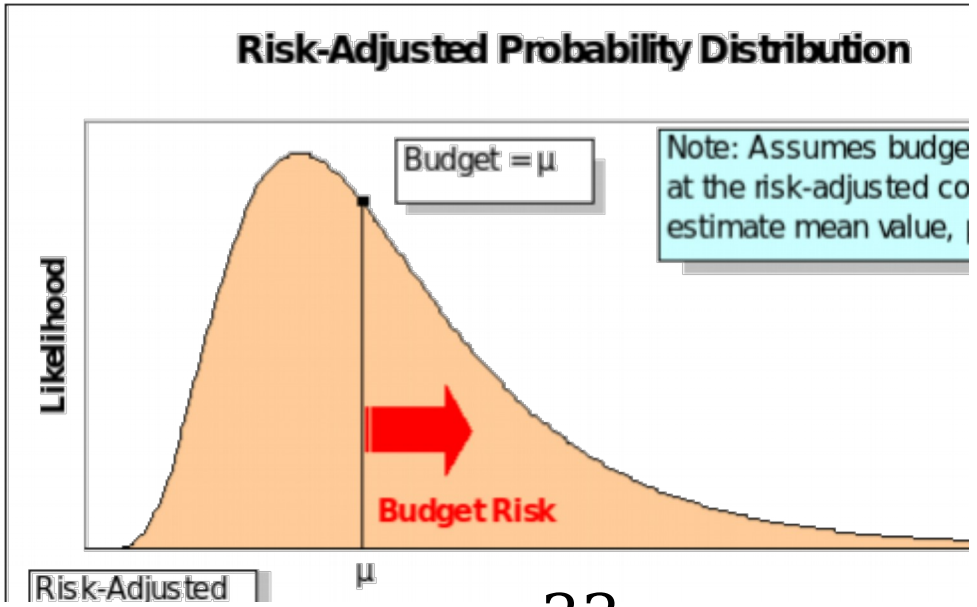

Y
Cost (e.g., software development)
Combined Cost Modeling Uncertainty and Technical Risk
Highest endpoint
Expected Cost = αX^β
Y = αX^β e^ε
Historical datum
Lowest endpoint
Mode
Mean
Low
High
X
Cost Driver (e.g., SLOC)
Input value from CARD

Sample Displays

- Normal distribution
  - Used for illustrative purposes
    - Good practice is to display PDF and cumulative distributions together
    - Good practice is to use “estimated” in labeling distributions



- Budget risk
  - Area to right of mean
    - Assuming budget set at mean



Verify & Validate Estimate

- Execute bottom-up scrub
  - Explain every calculation in the model to an independent, knowledgeable analyst
- Perform peer review
  - Explain the analysis, including generation of the point estimate and associated probability distribution, to subject matter experts
- Compare cost to analogous systems
  - Compare the life-cycle cost estimate to actual costs from similar programs
- Evaluate quality of risk and uncertainty analysis
  - Compare for consistency with other approaches and to historical CVs

Verification and validation, or V&V, is a quality control and assurance process. Verification helps ensure that the life-cycle cost estimate is credible, accurate, timely, and well documented. That is, verification focuses on the quality of the estimate, and its compliance with DON cost-estimating standards. Validation checks that the estimate meets stakeholder requirements. In short, validation ensures "doing the right estimate" while verification ensures "doing the estimate right."

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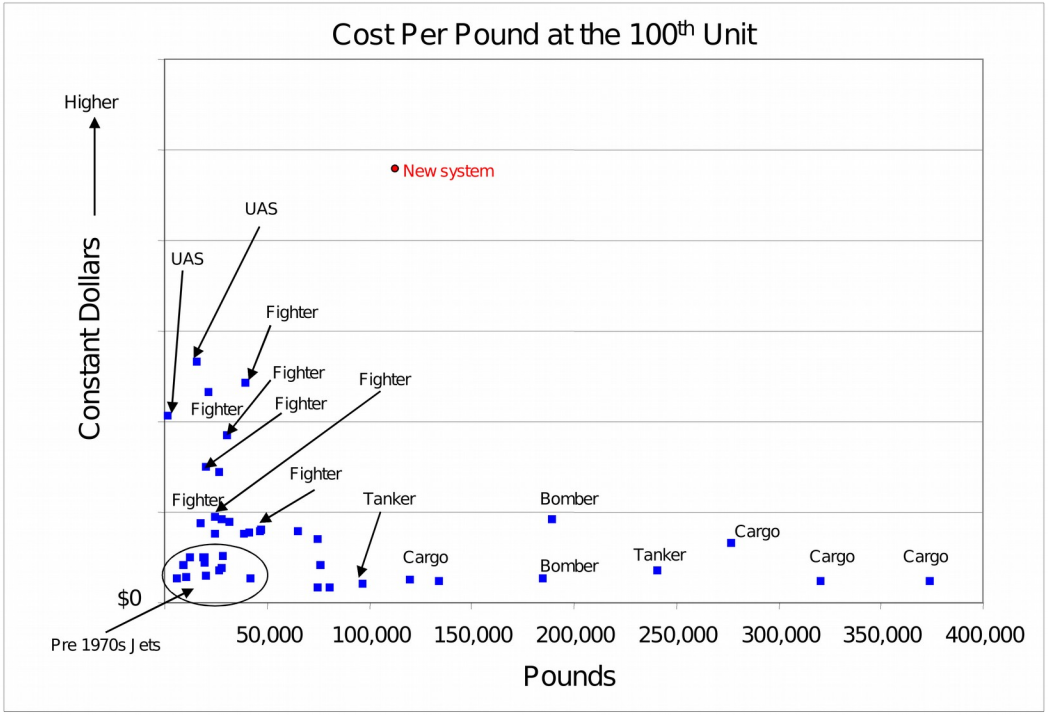
Verify & Validate Estimate

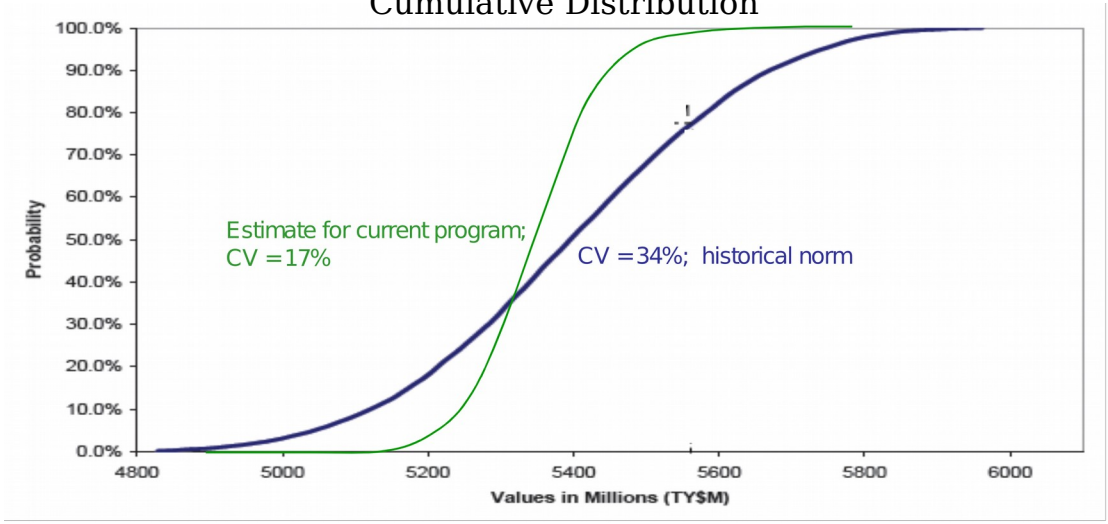
Compare the life-cycle cost estimate to actual costs from similar programs. This can be done at various levels of detail, with an example shown here. Metrics for comparison might include aggregate cost, dollars per pound, or system engineering/program management as a percentage of procurement cost. Explain anomalies. For example, an acquisition program with mature technology but "outlier" costs and one with advanced technology but "ballpark" costs might both raise flags.

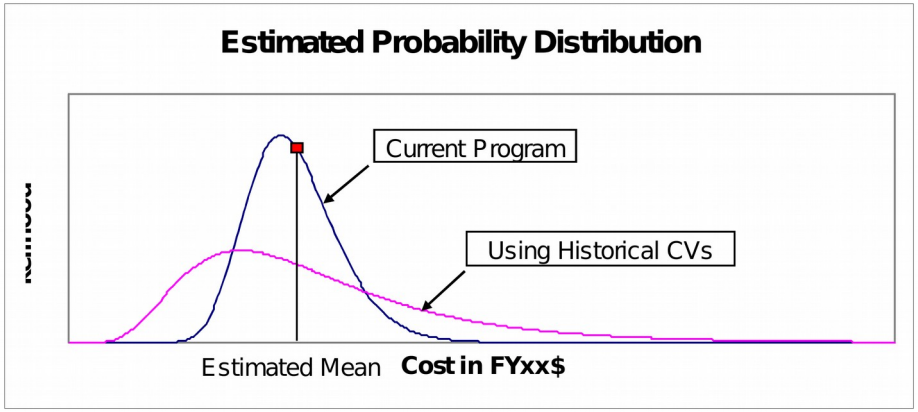


Verify & Validate Estimate

In cases where cumulative probability distributions are generated, compare the coefficient of variation (standard error divided by mean) for the estimate with estimated CVs from analogous programs at similar stages in the life cycle. Any significant variation in this normalized measure of dispersion of the probability distribution, from historical norms, could indicate a flaw in methodology. That is, either the acquisition program is free of risk to an unusual degree, or, alternatively, risk and uncertainty have not been properly taken into consideration in generating the cost estimate. In either case, an explanation is required.

Cumulative Distribution



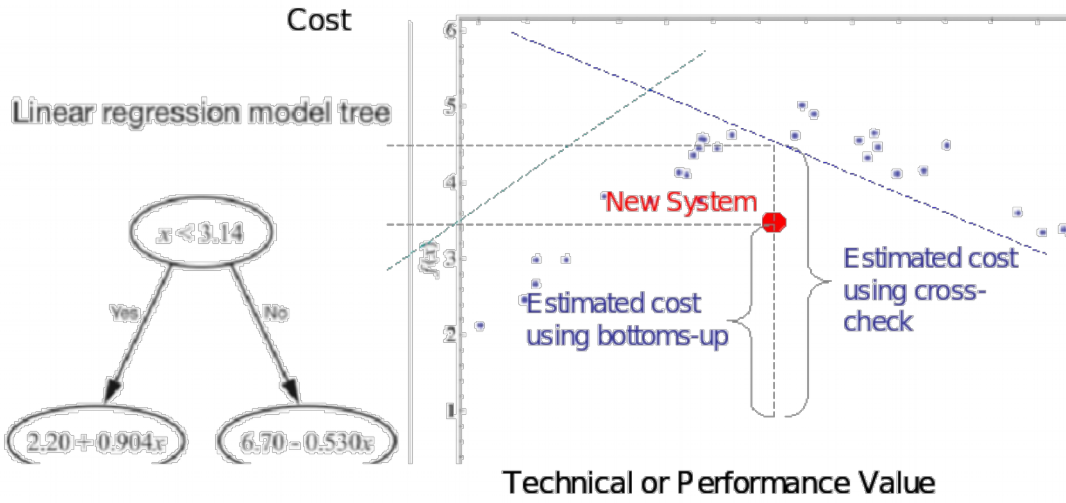


Probability Density Function

Verify & Validate Estimate

A more sophisticated cross-check, and a best practice, is to employ the results of top-level multivariate estimation, such as “decision trees and regression analysis,” with a simple two-leaf example of this application shown here. In this procedure, a vector of performance and technical characteristics of historical weapon systems are analyzed in terms of their impact on cost. The cost estimate from this verification model is compared to the point estimate generated from a different procedure, such as bottoms-up engineering or traditional parametric analysis. A flag is raised and explanation required if a new acquisition program produces anomalous results when feed into the decision-tree model.

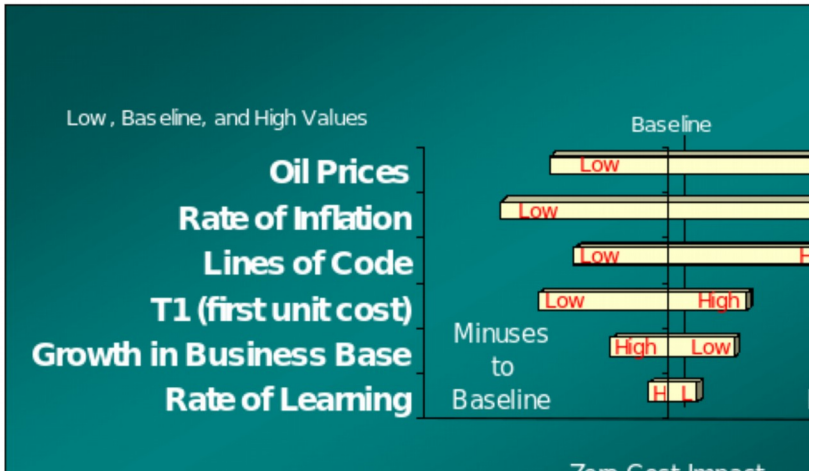
DON CES, pages 42 and 43



Dr. Bohdan Kaluzny of Defence Research and Development Canada; NATO SAS-076.

Present and Defend Estimate

- Complete the documentation process
  - This step entails completion of a process instituted from the “get-go”
- Develop presentation media
  - Demonstrate the thoroughness and professionalism of the effort
  - Show completeness and consistency
  - Explain ground rules and assumptions
  - Present findings in an understandable fashion
  - Convey the stochastic nature of the estimate
- Communicate and defend results
  - Through documentation and briefings
  - Depending on the skill and experience of the analyst, dry-runs might be required
  - Scripts, in some cases, might be useful



Example of the ubiquitous “tornado chart”